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(54) A NOZZLE FOR INTRODUCING GAS INTO LIQUID

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SPECIFICATION NO 1444027

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4 October 1977

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bubbles of gas, one such process being that of flotation. For example, it has been proposed in the water industry to use flotation techniques for clarifying impure water. In this process, the raw water is first treated with a coagulant, such as an iron or aluminium coagulant, to form a floc. Then flotation is effected by releasing into the liquid fine bubbles of a gas, suitably but not necessarily air. The bubbles of gas rise through the treated water to the surface, carrying with them the floc which forms a scum on the water surface and is subsequently removed.

In flotation processes of this type, it is advantageous to introduce the gas into the floc-containing water by first dissolving the gas under pressure in clarified, partially clarified or unclarified water, and then introducing the gas-in-water solution into the floc-containing water. The reduction in pressure causes release of the gas, generally in the form of microscopic gas bubbles. This procedure is known generally as "dissolved gas flotation" or more particularly "dissolved air flotation" where the dissolved gas is air.

It has been proposed to use needle valves for introducing the air-saturated water into the flocculated water, and whilst these valves are not wholly satisfactory for this purpose, their use does give rise to certain difficulties. For example, it has been found in practice that needle valves have to be carefully adjusted according to the precise conditions

liquid, said nozzle comprising a housing having a through-passage, said through-passage being defined by an inwardly-facing boundary surface, a pair of parallel dividing walls spaced apart along the through-passage to define a chamber therebetween, and an inlet orifice to said chamber formed in one wall and offset from an outlet orifice formed in the other wall, said passage both within and outside said chamber having its entire cross-section (as defined by said inwardly-facing boundary surface) open to the liquid, the arrangement being such that liquid flowing through the passage passes into the chamber through the inlet orifice, experiencing a reduction in pressure, and then, in order to pass through the outlet orifice, undergoes a substantial change in direction.

In passing through the chamber, the liquid impinges on the surfaces thereof and the liquid is thereby subjected to strong agitation and turbulence. Gas is released from the liquid as a result of the reduction in pressure at the inlet orifice and of the turbulence.

The mixture of gas and liquid leaves the chamber through the outlet orifice (which will generally be of larger diameter than the inlet orifice). There will usually be a slight pressure reduction as the mixture passes through the outlet orifice and this will tend to cause further release of dissolved gas from the liquid.

It will be appreciated that the dimensions

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(54) A NOZZLE FOR INTRODUCING GAS INTO LIQUID

(71) We, WATER RESEARCH CENTRE (formerly The Water Research Association), a British Company, of 45 Station Road, Henley-on-Thames, Oxon RG9 1BW (formerly of Ferry Lane, Medmenham, Marlow, Buckinghamshire), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with nozzles for introducing fine gas bubbles into a liquid.

There are many processes in which it is necessary to introduce into a liquid fine bubbles of gas, one such process being that of flotation. For example, it has been proposed in the water industry to use flotation techniques for clarifying impure water. In this process, the raw water is first treated with a coagulant, such as an iron or aluminium coagulant, to form a floc. Then flotation is effected by releasing into the liquid fine bubbles of a gas, suitably but not necessarily air. The bubbles of gas rise through the treated water to the surface, carrying with them the floc which forms a scum on the water surface and is subsequently removed.

In flotation processes of this type, it is advantageous to introduce the gas into the floc-containing water by first dissolving the gas under pressure in clarified, partially clarified or unclarified water, and then introducing the gas-in-water solution into the floc-containing water. The reduction in pressure causes release of the gas, generally in the form of microscopic gas bubbles. This procedure is known generally as "dissolved gas flotation" or more particularly "dissolved air flotation" where the dissolved gas is air.

It has been proposed to use needle valves for introducing the air-saturated water into the flocculated water, and whilst these valves are not wholly satisfactory for this purpose, their use does give rise to certain difficulties. For example, it has been found in practice that needle valves have to be carefully adjusted according to the precise conditions (pressure, rate of flow etc.) in order satisfactorily to cause the desired formation of gas bubbles. This is not an easy task especially when, for example, there are up to ten or more such valves in operation in a flotation tank. Also, needle valves have a tendency to become blocked and they are relatively costly to replace or repair when they become worn or otherwise faulty.

The present invention aims at overcoming the above difficulties and accordingly provides a nozzle for discharging pressurised gas-saturated liquid into a body of liquid to introduce fine gas bubbles into the body of liquid, said nozzle comprising a housing having a through-passage, said through-passage being defined by an inwardly-facing boundary surface, a pair of parallel dividing walls spaced apart along the through-passage to define a chamber therebetween, and an inlet orifice to said chamber formed in one wall and offset from an outlet orifice formed in the other wall, said passage both within and outside said chamber having its entire cross-section (as defined by said inwardly-facing boundary surface) open to the liquid, the arrangement being such that liquid flowing through the passage passes into the chamber through the inlet orifice, experiencing a reduction in pressure, and then, in order to pass through the outlet orifice, undergoes a substantial change in direction.

In passing through the chamber, the liquid impinges on the surfaces thereof and the liquid is thereby subjected to strong agitation and turbulence. Gas is released from the liquid as a result of the reduction in pressure at the inlet orifice and of the turbulence.

The mixture of gas and liquid leaves the chamber through the outlet orifice (which will generally be of larger diameter than the inlet orifice). There will usually be a slight pressure reduction as the mixture passes through the outlet orifice and this will tend to cause further release of dissolved gas from the liquid.

It will be appreciated that the dimensions

of the chamber and of the orifices and the position of the orifices are chosen so that there is a release of pressure as the liquid enters the chamber and the liquid is subjected to strong turbulence within the chamber as it passes therethrough. The precise dimensions suitable in any particular case can be found by routine trial and experiment.

One example of a nozzle of the invention will now be described, by way of illustration only, with reference to the accompanying drawing which is a longitudinal sectional view of one form of nozzle of the invention. Referring to the drawing, there is shown a transversely divided housing 1, 12 having a through-passage in the form of a cylindrical bore whose diameter is about 1 inch. Disposed diametrically within the housing are two discs, 2 and 3, spaced about $\frac{1}{4}$ inch apart by a spacer ring 6 and thereby forming a chamber 10. The two housing parts are releasably interengaged, for example, by screw threads to clamp the two discs and spacer ring therebetween. Disc 2 has an orifice 4 provided near the wall of inlet housing 1, the diameter of orifice 4 being about $\frac{1}{8}$ inch. Disc 3 is provided with an orifice 5 located close to the wall of outlet housing 12 and diametrically opposed to orifice 4. The diameter of orifice 5 is about $\frac{1}{4}$ inch. The housing, discs and spacer ring may suitably all be constructed from metal.

In use, pressurised air- or other gas-saturated water passes through orifice 4 at high velocity into chamber 10 where it impinges on disc 3. In flowing to outlet orifice 5 the water must change direction and impinge upon the cylindrical surface of chamber 10 and then again change direction before leaving chamber 10 via orifice 5. In passing through orifice 4 the pressure is greatly reduced. Impingement of water on the metal surfaces and changes in direction cause violent turbulence which in turn causes gas to come out of solutions in the form of minute bubbles which are particularly suited for use in the flotation process.

Finally, the water/gas mixture leaves chamber 10 via orifice 5. This is of larger diameter than orifice 4 since it is desirable that the greatest pressure drop should occur across orifice 4 (thus causing release of the major proportion of the dissolved gas within chamber 10).

It will be noted that the through-passage of the nozzle is defined, throughout its length, by an inwardly-facing boundary surface, the entire cross-section (as defined by this surface) being open to the liquid.

We have found that a nozzle of the above dimensions produces very satisfactory results for an air-saturated water flow rate of from about 80 to more than 150 gallons per hour.

When used for water clarification by means of a dissolved gas flotation it is generally preferred that a shrould member be provided downstream of the exit orifice so that the velocity of the gas/water mixture be reduced to a value close to that of the flocculated water into which it passes. In this way, entry of the gas/water mixture in the flocculated water will not cause too much turbulence and break up the floc. The shroud member can suitably be made as an integral part of the exit housing 12 as shown.

It will be clear to those skilled in the art that there are a number of ways in which the discs can be mounted and description of these several methods will not therefore be given. It is, of course, preferred that the discs be mounted so as to be readily replaceable, for example, for maintenance or cleaning purposes.

The positions of the orifices in the illustrated embodiment are merely illustrative of one particular arrangement, and there are we believe many other suitable arrangements. Also, it is possible to have more than one inlet orifice and/or more than one exit orifice.

The described nozzle for introducing fine gas bubbles into a liquid, is of simple construction, is less likely (than a needle valve) to become blocked, is relatively cheaply made and maintained and does not require frequent adjustment in use. In addition, it is very efficient in causing the release of dissolved gas.

Attention is drawn to our co-pending application 36854/73 (Serial No. 1,444,026) which describes and claims a method of clarifying impure water.

WHAT WE CLAIM IS:—

1. A nozzle for discharging pressurised gas-saturated liquid into a body of liquid to introduce fine gas bubbles into the body of liquid, said nozzle comprising a housing having a through-passage, said through-passage being defined by an inwardly-facing boundary surface, a pair of parallel dividing walls spaced apart along the through-passage to define a chamber therebetween, and an inlet orifice to said chamber formed in the other wall, said passage both within and outside said chamber having its entire cross-section (as defined by said inwardly-facing boundary surface) open to the liquid, the arrangement being such that liquid flowing through the passage passes into the chamber through the inlet orifice, experiencing a reduction in pressure, and then, in order to pass through the outlet orifice, undergoes a substantial change in direction.

2. A nozzle according to claim 1, wherein said through-passage comprises a cylindrical bore.

3. A nozzle according to claim 2, wherein each said individual wall comprises a disc.

4. A nozzle according to claim 3, where-

in the two discs are spaced apart by a spacer ring.

5. A nozzle according to claim 4, wherein the housing is transversely divided into two parts which interengage to clamp the discs and spacer ring therebetween.

6. A nozzle according to any one of the preceding claims, wherein each dividing wall is spaced from the end adjacent thereto of said through-passage.

7. A nozzle according to any one of the preceding claims, wherein the inlet orifice is smaller than the outlet orifice.

8. A nozzle substantially as herein described with reference to and as shown in the accompanying drawing.

9. A nozzle according to any one of the preceding claims in combination with a water clarification tank.

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1444027 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*